THE ATTRACTION OF DIPTERA TO AMMONIA.

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During the course of experiments on the responses of the house-fly to certain chemical compounds, data were gathered concerning the reactions of some other species that entered the traps with more or less regularity. It is the purpose of this article to give the results of these experiments and to include brief summaries of the literature concerning the olfactory tropisms of insects.

It has long been recognized that the olfactory organs of insects are of primary importance in the search for food and for breeding places, in the assembling of the sexes, and in the reactions to certain repulsive smelling substances. The experimental study of these responses to environmental odors, neglected by entomologists in the past, has recently awakened an interest which promises important results.

Tragardh (1913) and Imms (1914) have published in England valuable resumes of the literature touching upon this subject, but I believe no fairly comprehensive bibliography has yet been placed before American students.

One of the earliest contributions to odor responses was made by Barrows (1907) on the pomace-fly, *Drosophila ampelophila* Loew. It was found that the flies responded positively to aqueous solutions of amyl alcohol, ethyl alcohol, acetic acid, lactic acid, and acetic ether. When acetic ether was added to acetic acid or ethyl alcohol, more flies were captured than when acetic acid or ethyl alcohol was used alone. A similar phenomenon was observed when isobutyl acetate or methyl acetate was mixed with ten per cent ethyl alcohol or when acetic, butyric or valerianic acid was added to ethyl alcohol. The strong mineral acids, nitric and hydrochloric, were very repellent. A solution containing two and one-half per cent. of ethyl alcohol and five-eighths per cent. of acetic acid called forth the greatest number of positive reactions. Ethyl alcohol and acetic acid are found in cider vinegar, fermented cider and California sherry in percentages close to those which induced maximum

reactions in *Drosophila*. The author ascertained also that the olfactory organs in *Drosophila* which are concerned with the location of food are situated in the third or terminal segments of the antennæ. When stimulated by a weak food odor the flies responded by random movements, but as they passed into an area of greater stimulation, they became directly oriented and proceeded toward the source of the odor.

Verschaffelt (1910) has published an important paper on the compounds that determine the selection of food in larvæ of *Pieris brassicæ* and *Pieris rapæ*. These larvæ feed upon certain Cruciferæ as well as *Tropaeolium* and *Reseda*, plants which contain a group of glucosides, the mustard oils. A solution of sinigrin, one of these mustard oils, when spread upon foliage which the larvæ ordinarily refused caused them to devour it readily. The larvæ of a sawfly, *Priophorus padi*, which feed upon the leaves of certain Rosaceæ, were attracted by amygdaline, a glucoside found in these plants.

Howlett (1912) attracted fruit-flies of the genus *Dacus* to rags moistened with oil of citronella. Only the males responded to this odor and he was able to show quite conclusively that the females emit an odor closely resembling the oil of citronella. In other experiments he induced a species of *Sarcophaga* to deposit larvæ in a flask containing a solution of skatol, a compound present in the feces of many animals. He also found that *Stomoxys calcitrans* L. would oviposit on cotton-wool which had been soaked in valerianic acid and that both valerianic and butyric acids were similarly attractive to an ortalid fly of the genus *Ulidia* (?). The work was done at Pusa, India.

The same author (Howlett, 1914) demonstrated the attractiveness of benzaldehyde, cinnamylaldehyde and anisaldehyde to two undetermined species of thrips. Salicylaldehyde and isobutylaldehyde were also tried, but the results from these were not so striking. The experiments were conducted in England during the months of November and December, when thrips are not abundant. The author believes larger catches would be obtained in summer.

The Severins (1914, a and b), have studied the attractiveness of various oils to the Mediterranean Fruit-fly, *Ceratitis capitata* Wied. in the Hawaiian Islands. Kerosene was used as a bait in many experiments and it was found that most of the flies captured were males. Indeed in eight month's trapping an

average of only three females was obtained in every thousand flies caught. Traps were colored white, black, blue and orange, but the size of the catches did not appear to depend on the color of the trap. Traps placed under trees whose fruits had a readily accessible supply of juice (Java plum) caught the largest number of flies, but flies were often caught in traps wired to trees not in fruit or which bore fruit not sought by the flies. Petroleum oils containing comparatively large amounts of volatile hydrocarbons were most readily sought while the heavier burning and lubricating oils were less attractive. Oil of citronella and turpentine had a very slight attraction, cocoanut oil had none. Whale and fish oils were not visited by the flies. The alluring properties of petroleum oils are probably due to one or more of the volatile hydrocarbons or to some of the impurities such as the sulphur or nitrogen constituents. While admitting that these attractive oils may give off an odor which resembles that emitted by the female fly, it is stated that the tropism may be one not associated with sex.

Chatterjee (1915) found that kusum oil from the berries of the tree, *Schleichera trijuga* attracted nymphs and adults of both sexes of a coried, *Serinetha augur*. A few drops of the oil scattered about on any suitable object was sufficient to allure large numbers of the bugs. The experiments were conducted at Dehra Dun, India.

I have recently published results of experiments on the attractiveness of ammonia and certain other chemical compounds to the house-fly *Musca domestica* L (Richardson, 1916, a. and b.). Ammonia from commercial ammonium carbonate and ammonium hydroxide was attractive to females, but was visited by few males. Eggs were deposited on the following materials when ammonium carbonate was added to them: acidulated horse manure (treated with dilute hydrochloric acid so that all the volatile ammonia was converted into the non-volatile ammonium chloride), moist timothy chaff, moist pine sawdust and moist cotton. However cotton was scarcely attractive without further addition of butyric or valerianic acid. Horse manure was the most attractive, pine sawdust and cotton the least. The house-fly apparently has some means of discriminating between substances which can and those which can not furnish food for its larvæ.

It will be noted that the activating substances where their exact chemical nature has been determined, are for the most part organic compounds, some of considerable complexity. Ammonia is the only one among these which is not a carbon compound, and it is the simplest in molecular structure.

THE EXPERIMENTS.

The flies were captured in screen wire traps nine and three-fourths inches high and six inches in diameter at the base. Pieces of commercial ammonium carbonate were placed in glass dishes in the pan of the trap and a little water was usually added to each glass dish. Ten experiments involving twenty-three traps, each containing from eighty-five to two hundred and thirty-four grams of ammonium carbonate and seventeen controls with or without water were carried out during the summer. The results, exclusive of house-flies caught are given in the following table:

TABLE A.

	Traps containing ammonium carbonate Number caught	Control traps Number caught
Phorbia sp.	15	
Muscina stabulans	11	
Ravinia communis	1	2
Fannia canicularis	1	
Lucilia sericata	1	1
Ophyra leucostoma	2	
Stomoxys calcitrans	3	
Leptocera ferruginata	106	
Sepsis minuta	2	

An ortalid, *Leptocera* (*Limosina*) *ferruginata* Steub. was a frequent visitor to the traps and an undetermined *Phorbia* and *Muscina stabulans* Fall. were caught often enough to suspect they were attracted by the odor of ammonia. *Leptocera* is so small that it can pass through the meshes of the trap screen readily and only those individuals that fell into the solution were captured. Had the meshes been small enough to retain the flies which entered the traps, I believe the number would have been far larger. In the oviposition experiments with the house-fly, *Leptocera*, was almost always present, running about in the dishes containing ammoniated manure, timothy chaff and pine sawdust and even coming to those which held the ammoniated cotton. It was an abundant species in accumulations of horse manure at New Brunswick. *Sepsis minuta* Wied.

was also seen about the traps and experimental dishes frequently, but for some reason few individuals were caught. Several other species were captured in small numbers, but have not yet been identified.

Stomoxys calcitrans L. was not caught often in ammonia traps and I was not able to get it to oviposit on cotton soaked in valerianic acid, although Howlett did succeed in this at Pusa, India. Howlett does not give the details of his experiments further than to say that he used "cotton-wool soaked in valerianic acid." (Howlett, 1912, p. 416).

One trap experiment and eight oviposition experiments with valerianic acid were completed during the summer of 1915 at New Brunswick. The traps and method of using them have been described above. The oviposition experiments were performed in porcelain evaporating dishes, 120 mm. in diameter. A piece of sterilized absorbent cotton was placed in each, to the surface of which the acid and usually water were added. The experiments were carried out at various times on the window sills of a laboratory or on a bench near a livery stable. Frequent observations showed that *Stomoxys* was present in these localities throughout the course of the experiments. The results of the valerianic acid experiments are set forth in the following table:

TABLE B.

TRAP EXPERIMENT.

Amount of material.	Number of traps	Duration of experiment	Result
50 cc. valerianic acid	1	67 hrs.	No *Stomoxys*
50 cc. distilled water	1	"	"

OVIPOSITION EXPERIMENTS.

Amount of material	Number of experimental dishes	Duration of experiment	Result
10 cc. valerianic acid+cotton	1	46 hrs.	No eggs
2 cc. valerianic acid+cotton+50 cc. water	1	45 hrs.	"
5 cc. valerianic acid+cotton+50 cc. water	1	45 hrs.	"
" " " "	1	46 hrs.	"
" " " "	1	23 hrs.	"
" " " "	1	22 hrs.	"
" " " "	1	18 hrs.	"
" " " "	1	3 hrs.	"

Stomoxys did not lay eggs on cotton treated with valerianic acid in these experiments and it was never seen attempting to do so, nor was it ever observed hovering about the dishes.

The odor of two cubic centimeters of the acid diluted with fifty cubic centimeters of water was easily perceptible to a man at a distance of fifteen feet from the dish.

While my results do not agree with Howlett's, this may be due to the fact that we used different methods, or even to some dissimilarity in the responses of *Stomoxys* in the two regions. One can conceive of the same species of insect attuned to respond to certain odors in one environment, responding to very different odors in another.

CONCLUSION.

The odor of ammonia attracts a varied dipterous aggregation. The species which respond to it are known to spend at least a part of their lives in some form of animal excrement. Practically all animal excrement gives off ammonia during some stage in its decomposition. These flies are probably lured to the manure chiefly by the odor of this gas. The response is not always a simple one, but is sometimes complicated by other factors, as has been shown in the studies on *Musca domestica* L. referred to above.

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